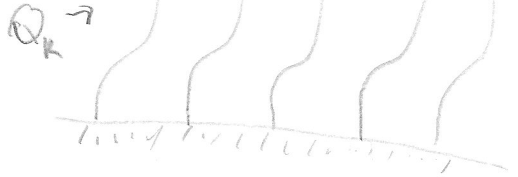
(RG) Strongly stratified "two-layer" estuaries

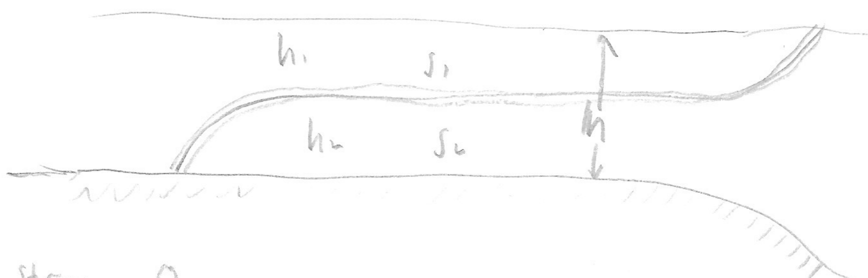
8/8/2019

(1)

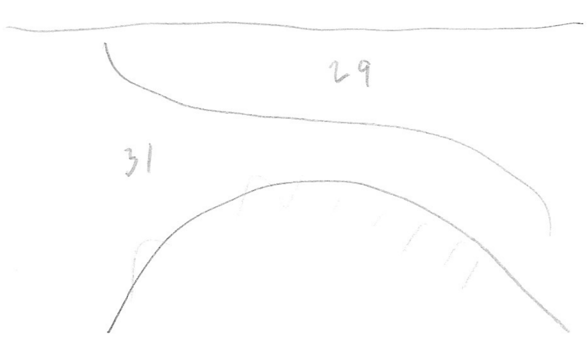


as it gets more stratified

the "identity" of the water depends on which layer it is in

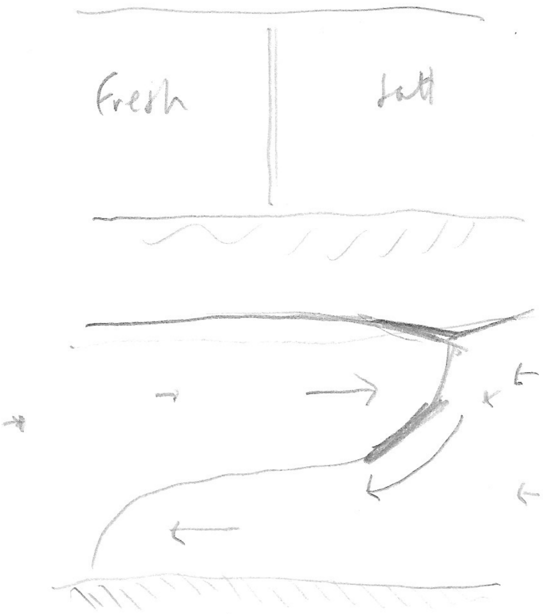


- Strong Q_R
- Weak mixing
- water does not stay in the estuary very long so it doesn't have time to mix



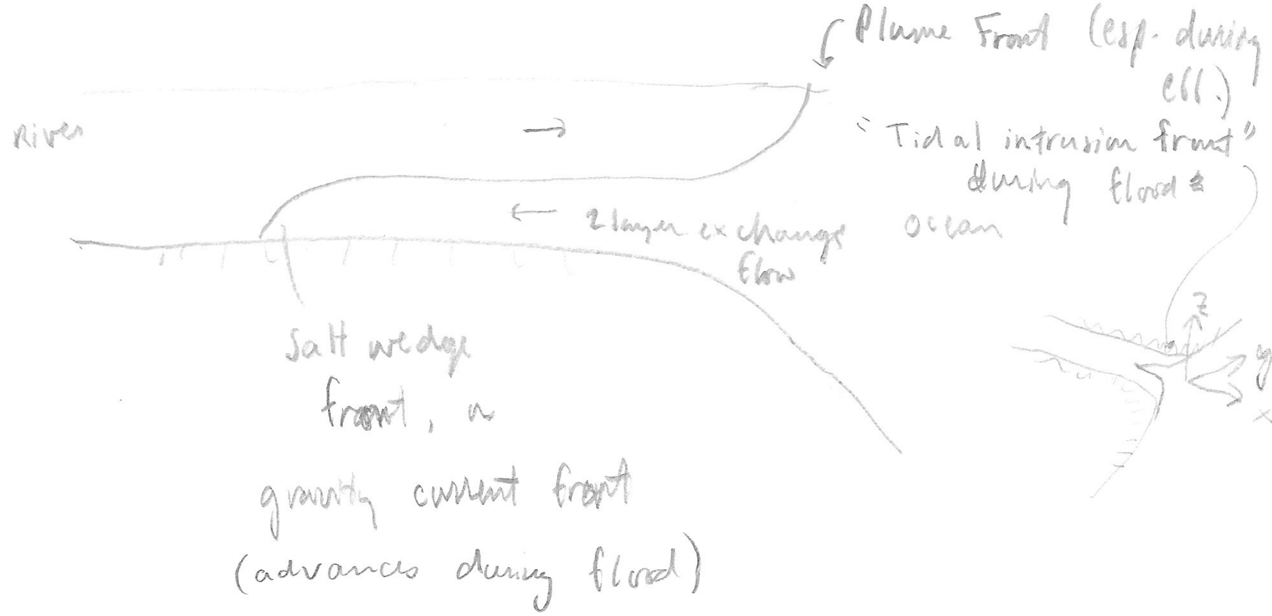
Flow over a sill
- 2 layers even though 1 is not fresh.

lock exchange problem

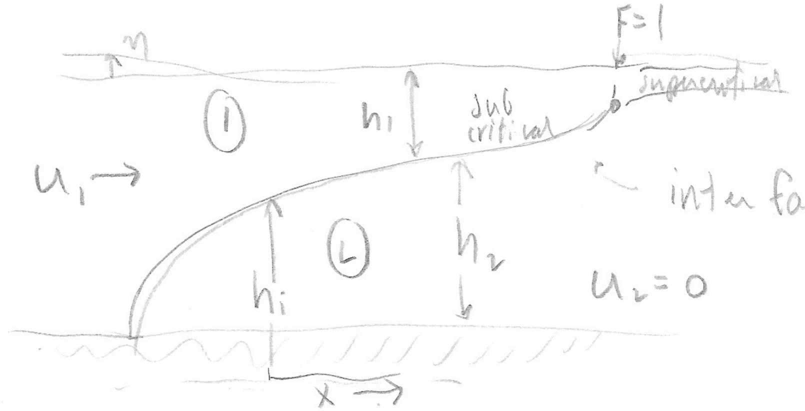


the two types of water may have been created elsewhere, and then meet because of some physical situation, like flow separation.

estuary:



Schijf & Shoenfeld (1953) solution(s)



arrested salt wedge

$\Delta u = u_1 - u_2$

$$u_1 u_{1x} + g\eta_x + \frac{C_i |\Delta u| \Delta u}{h_1} = 0$$

$$g\eta_x + g' h_{ix} - \frac{C_i |\Delta u| \Delta u}{h_2} = 0$$

Interfacial friction but no entrainment (actually, what entrainment there is is in the interface - and is removed rapidly?)

$h_{ix} \sim$ 50 times steeper than η_x

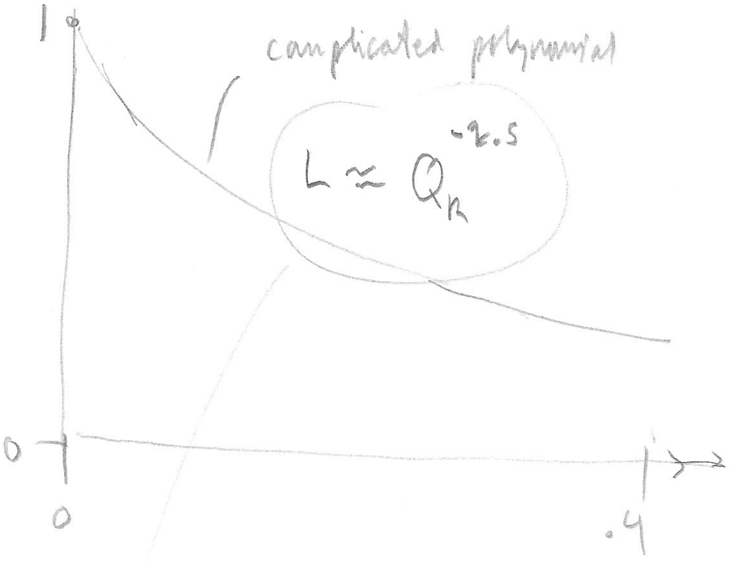
$C_i \approx 1-4 \times 10^{-4}$

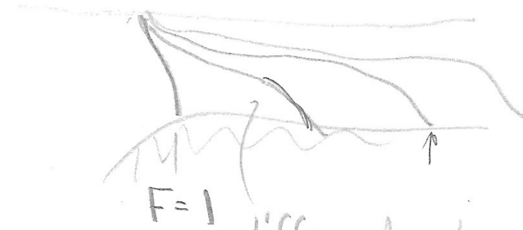
Fw. Froude # $\quad Fr_f = \dfrac{u_f}{\sqrt{g' h_0}} \sim 1$

$u_f = u_r + u_T$ $\quad \left\{ \begin{array}{l} u_r \sim 0.4 \text{ m/s} \\ u_{T\,(\text{tidal})} \sim 1 \text{ m/s} \end{array} \right\}$ 1.4 m/s $\quad$ different answer at other phases of the tide

F

$= \frac{u_f}{(g'h_0)^{1/2}}$





different phase of the tide.

length of salt intrusion

$\frac{c_i L}{h_0}$

0 20 km 40 km

so this is much more sensitive to Q_R compared to the partially mixed result $L \sim Q_R^{-1/3}$

It is more sensitive because of the advective terms.

$$\underset{ⓐ}{u_{1t}} + \underset{ⓑ}{u_1 u_{1x}} + g\eta_x \;\ldots$$

$$\omega[u_1] \qquad \frac{[u_1^2]}{L}$$

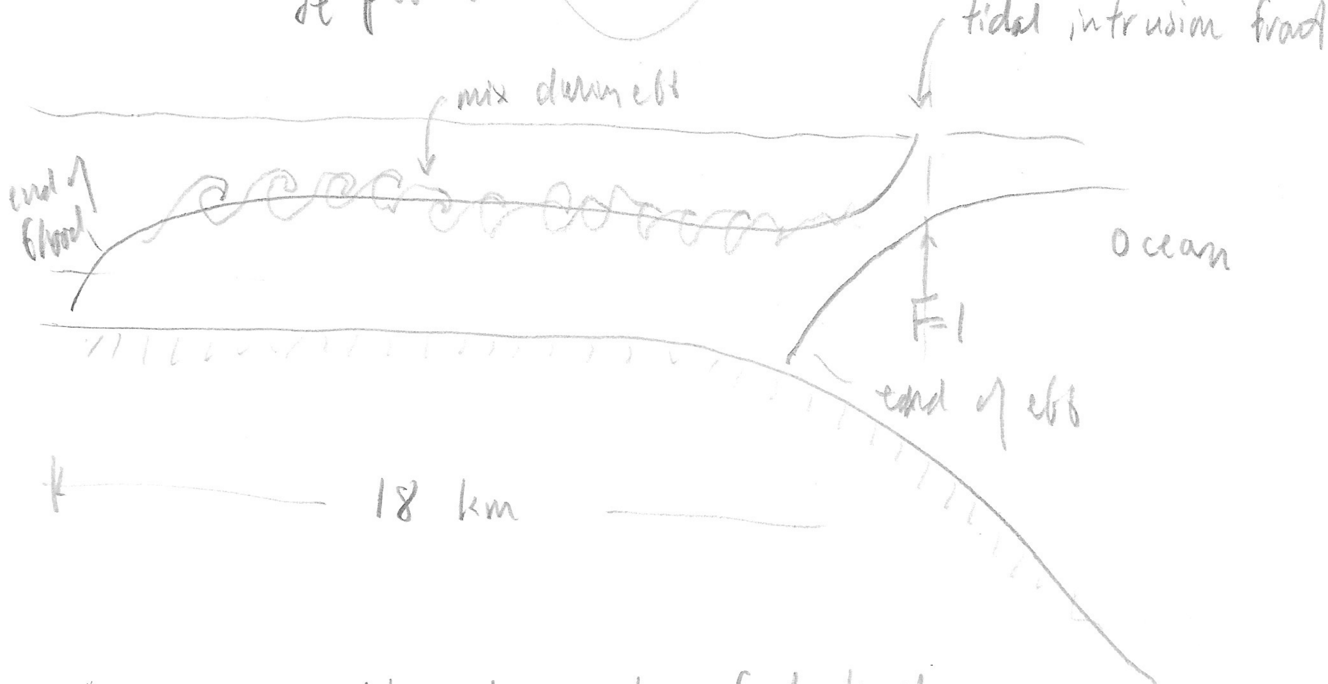
$$\frac{ⓐ}{ⓑ} = \frac{\omega L}{u} \sim 1.4$$

ω: $1.4 \times 10^{-4}\ s^{-1}$

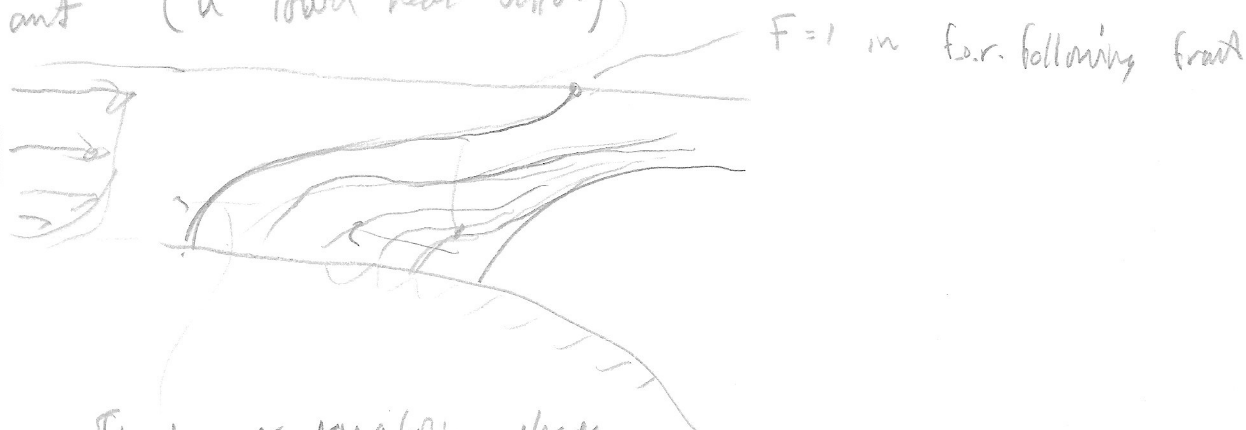
L: 10^4 m (Fraser River)

u: 1 m/s

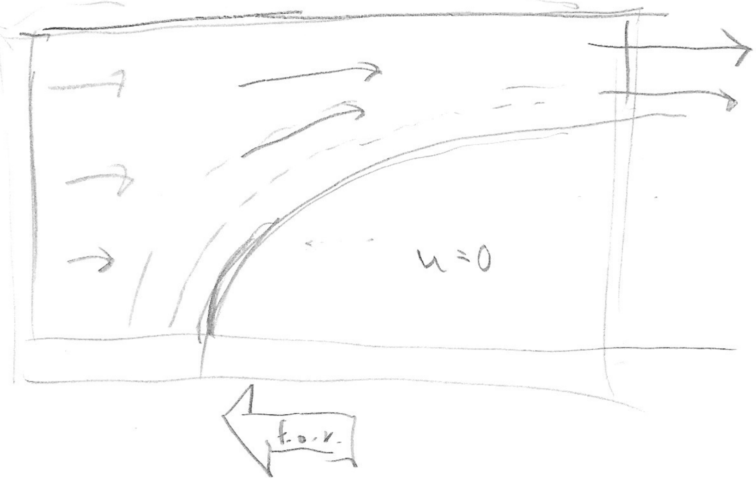
$\Rightarrow$ at the peak tidal acceleration time dependence is important



Advancing salt wedge - the fact that there is a log layer in the river is important (u lower near bottom)



Flood: ~ parabolic shape moves up estuary without changing shape



In f.o.r. moving with the intruding salt wedge front

① $u_1 \cancel{u_{1x}} + \underbrace{\cancel{g\eta_x}}_{\Rightarrow 0} = 0$ neglect for thick upper layer so u_1 small

② $g' h_{1x} + \dfrac{C_D |u_2| u_2}{h_2} = 0$

or $g' h_{2x} + \dfrac{C_D |u_2| u_2}{h_2} = 0$

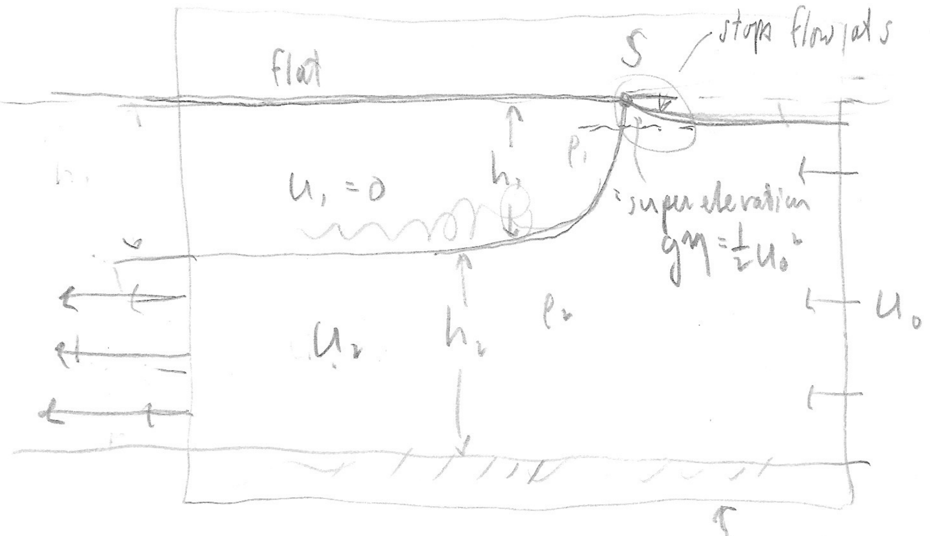
at the nose the interface gets steeper

as the friction term increases like $\dfrac{1}{h_2}$

$h_2 \sim \sqrt{x}$

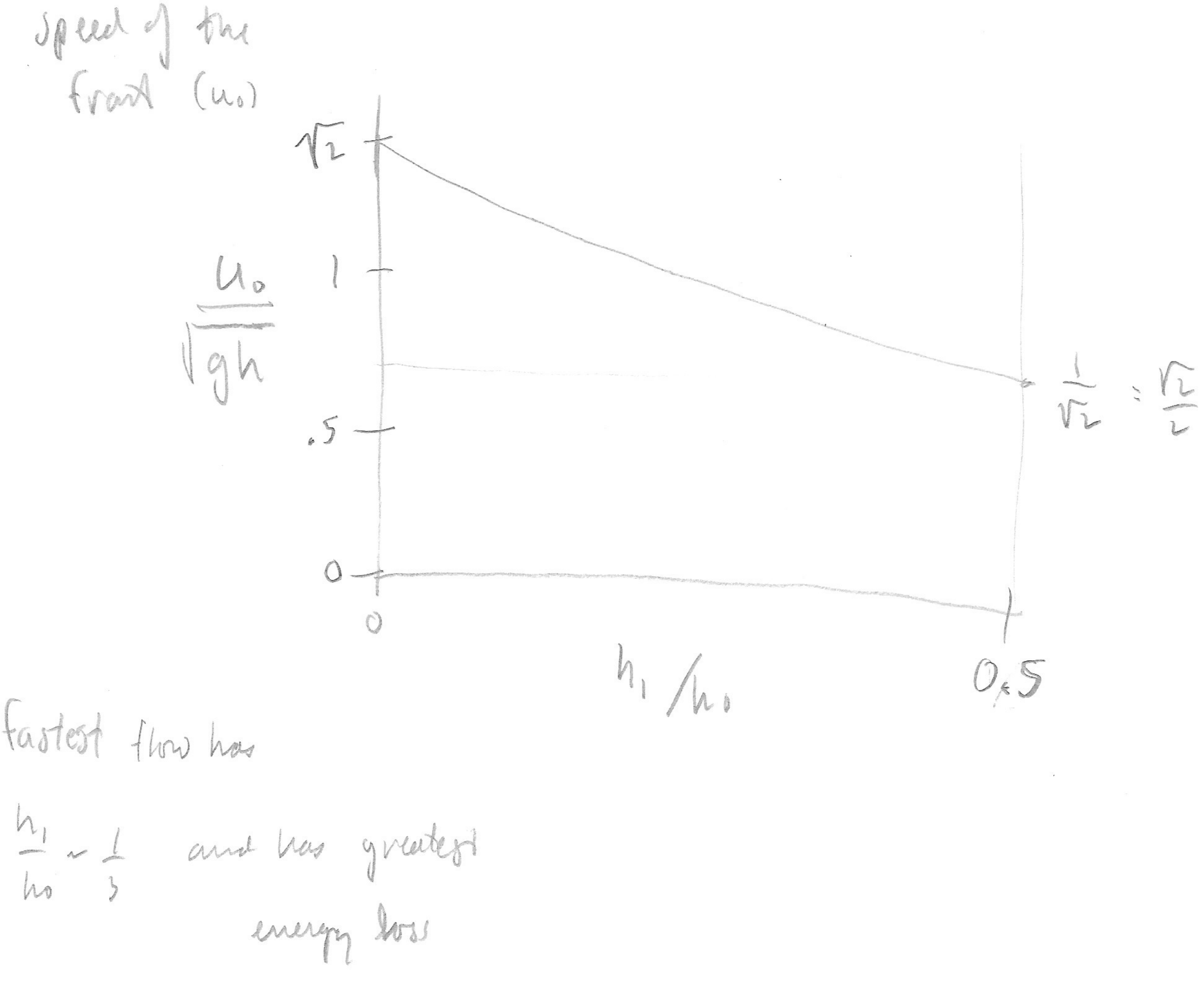
Nose is non-hydrostatic

Benjamin solution to gravity current (in far. of current nose)



S = stagnation point

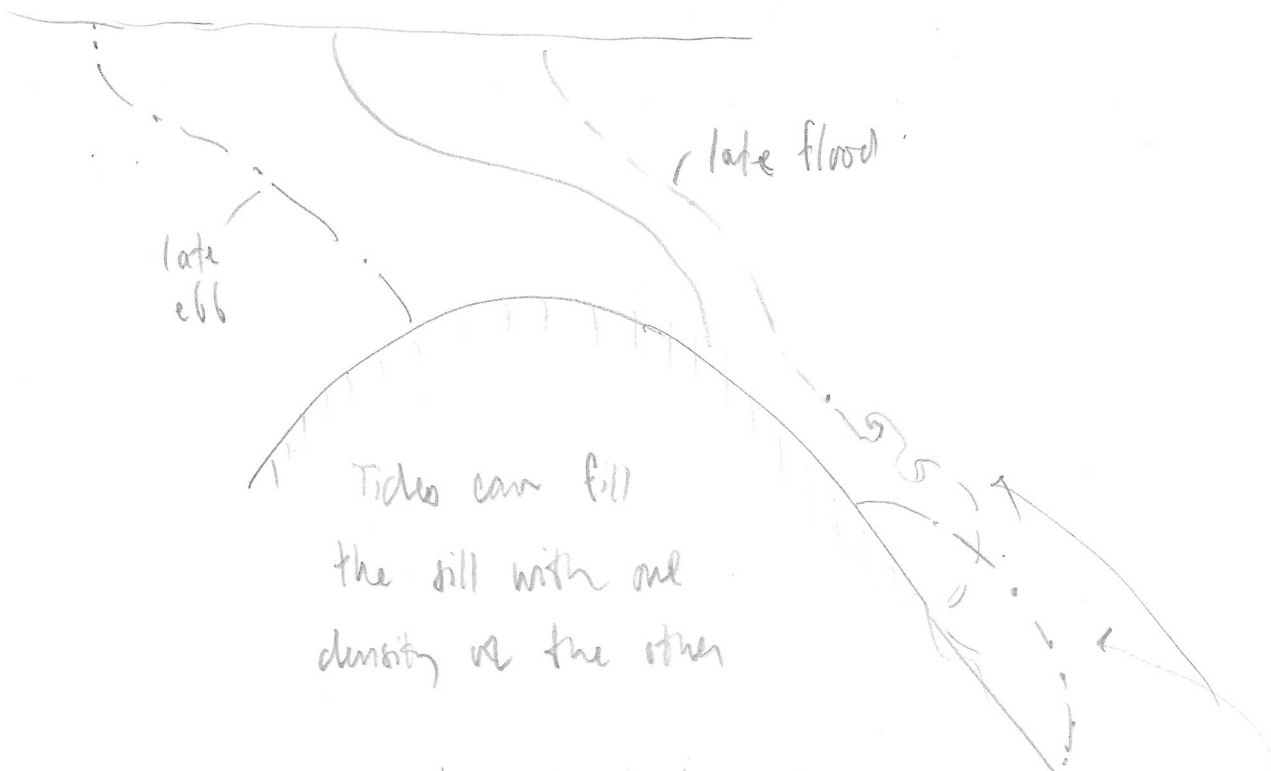
non hydrostatic



fastest flow has

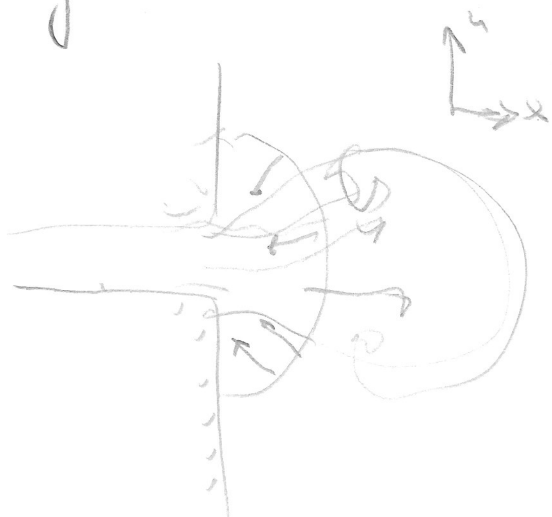
$\frac{h_1}{h_0} \sim \frac{1}{3}$ and has greatest energy loss

Fjord w/ tides



We look for mechanisms that keep the same water from coming back – like a gravity current down a steep slope.

Or plume dynamics



Benjamin → Website